DTU Library

Maskless Nanostructure Definition of Submicron Rear Contact Areas for Advanced Solar Cell Designs

Davidsen, Rasmus Schmidt; Schmidt, Michael Stenbæk; Boisen, Anja; Hansen, Ole

Publication date:
2015

Document Version
Publisher's PDF, also known as Version of record

Maskless Nanostructure Definition of Submicron Rear Contact Areas for Advanced Solar Cell Designs

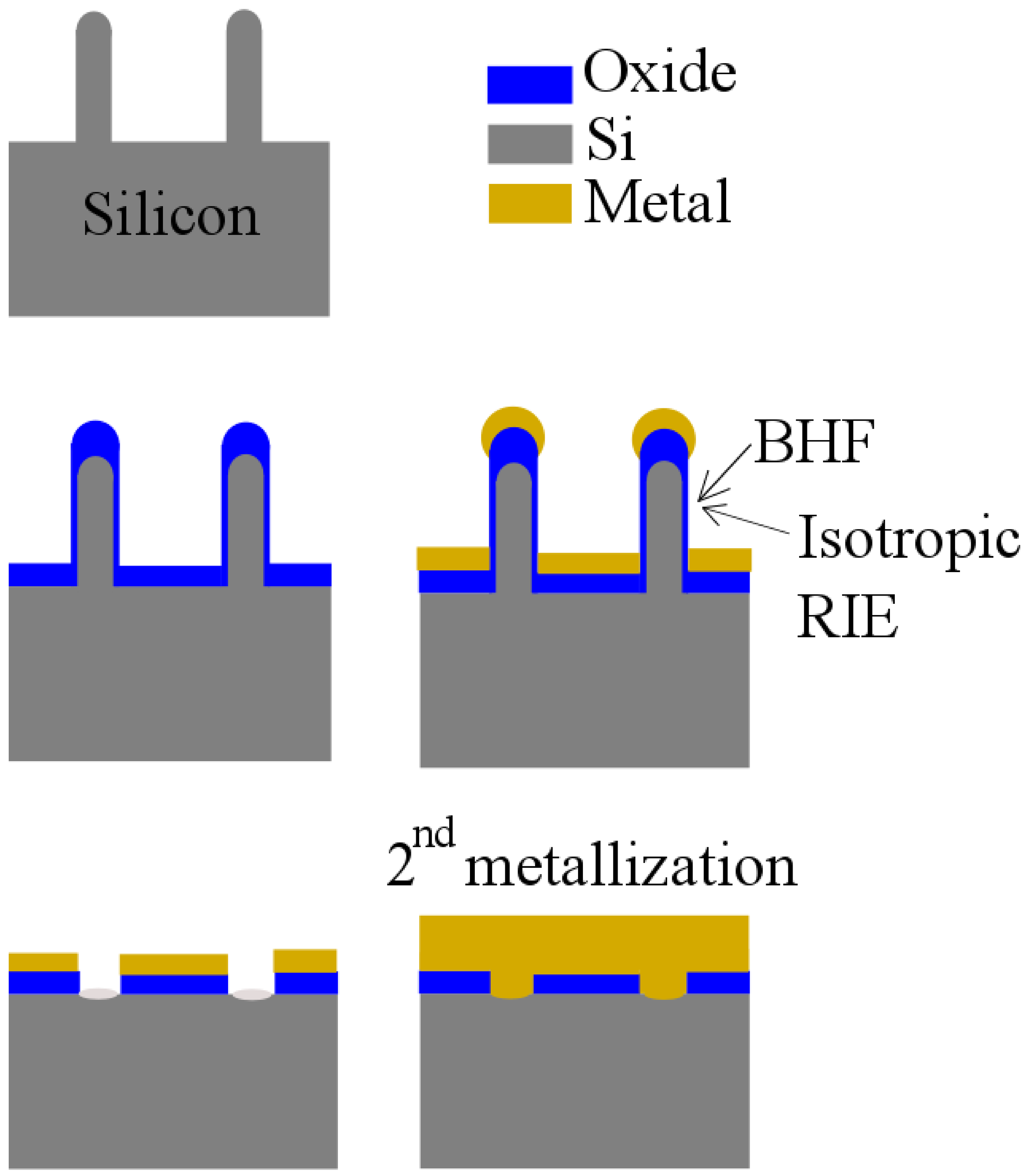
Rasmus Schmidt Davidsen[*,a], Michael Stenbæk Schmidt[a], Anja Boisen[a], Ole Hansen[a]

[a]DTU Nanotech, Technical University of Denmark, Ørsteds Plads 345, 2800 Kgs. Lyngby, Denmark

*e-mail: rasda@nanotech.dtu.dk

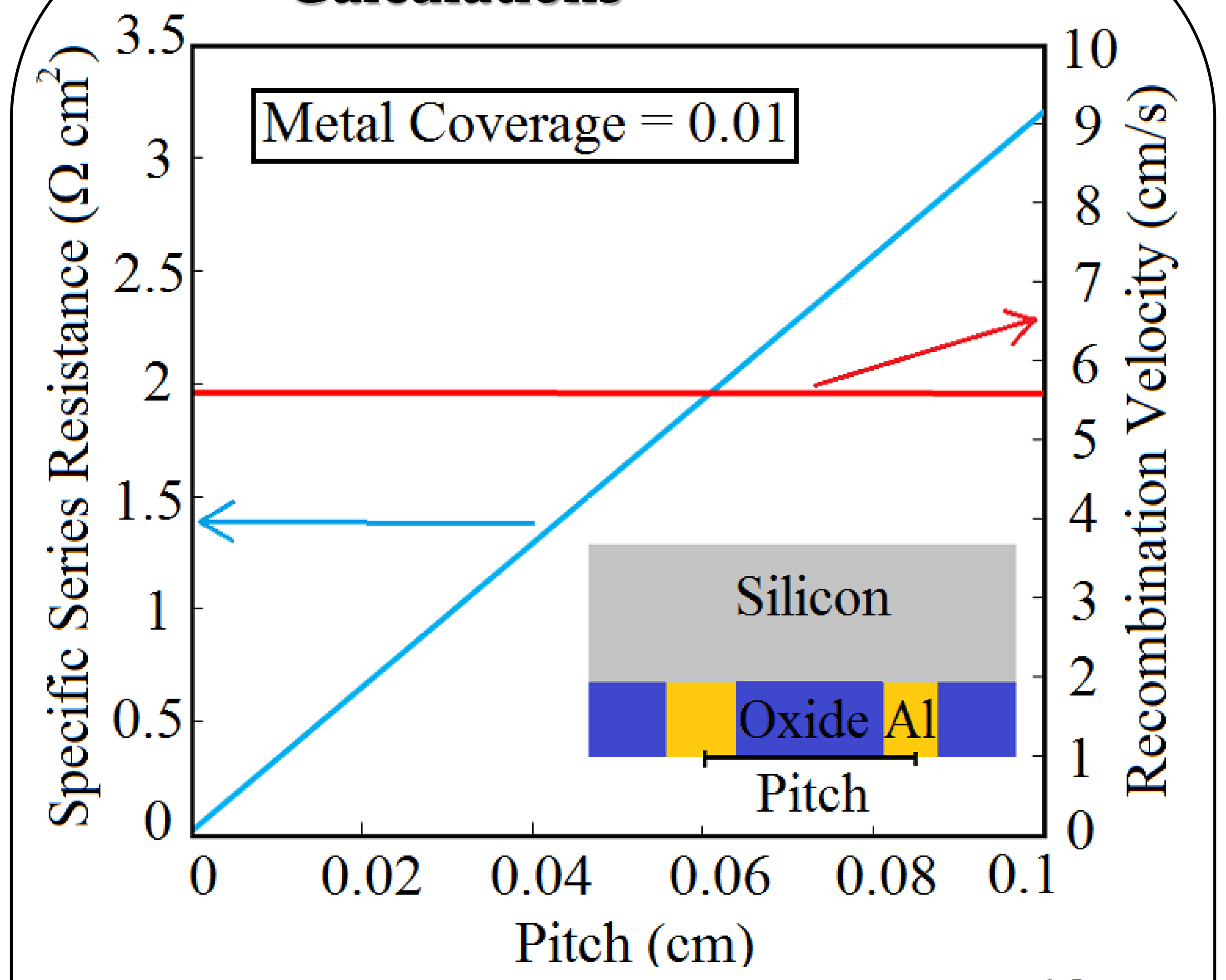
Concept

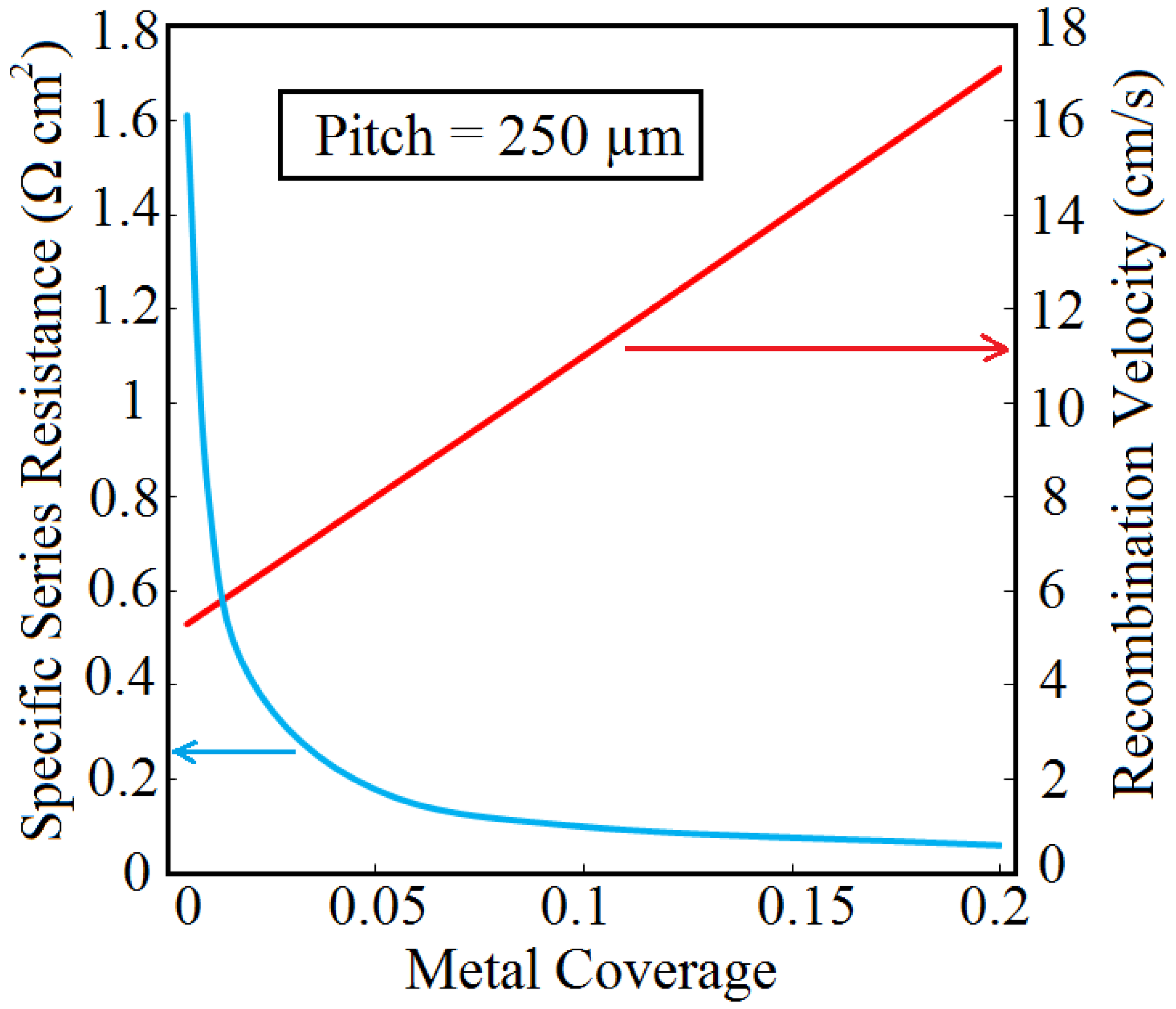
Nanostructures are fabricated by maskless reactive ion etching (RIE) [1,2] using SF_6 and O_2 ions. Maskless RIE enables precise definition of nanostructured topologies with specific pitch and size without the use of photolithography. The optimal rear design of the world-record passivated emitter rear locally diffused (PERL) solar cell [3] is a compromise between minimized series resistance, requiring some metallization, and minimized SRV, requiring passivation.
We present a completely maskless process for controlled definition of submicron local contact areas on a passivated Si surface.



Sketch of the process flow consisting of maskless nanopillar etch, passivation, Al evaporation, isotropic RIE of pillar sidewalls and 2nd metallization plus optional doping.

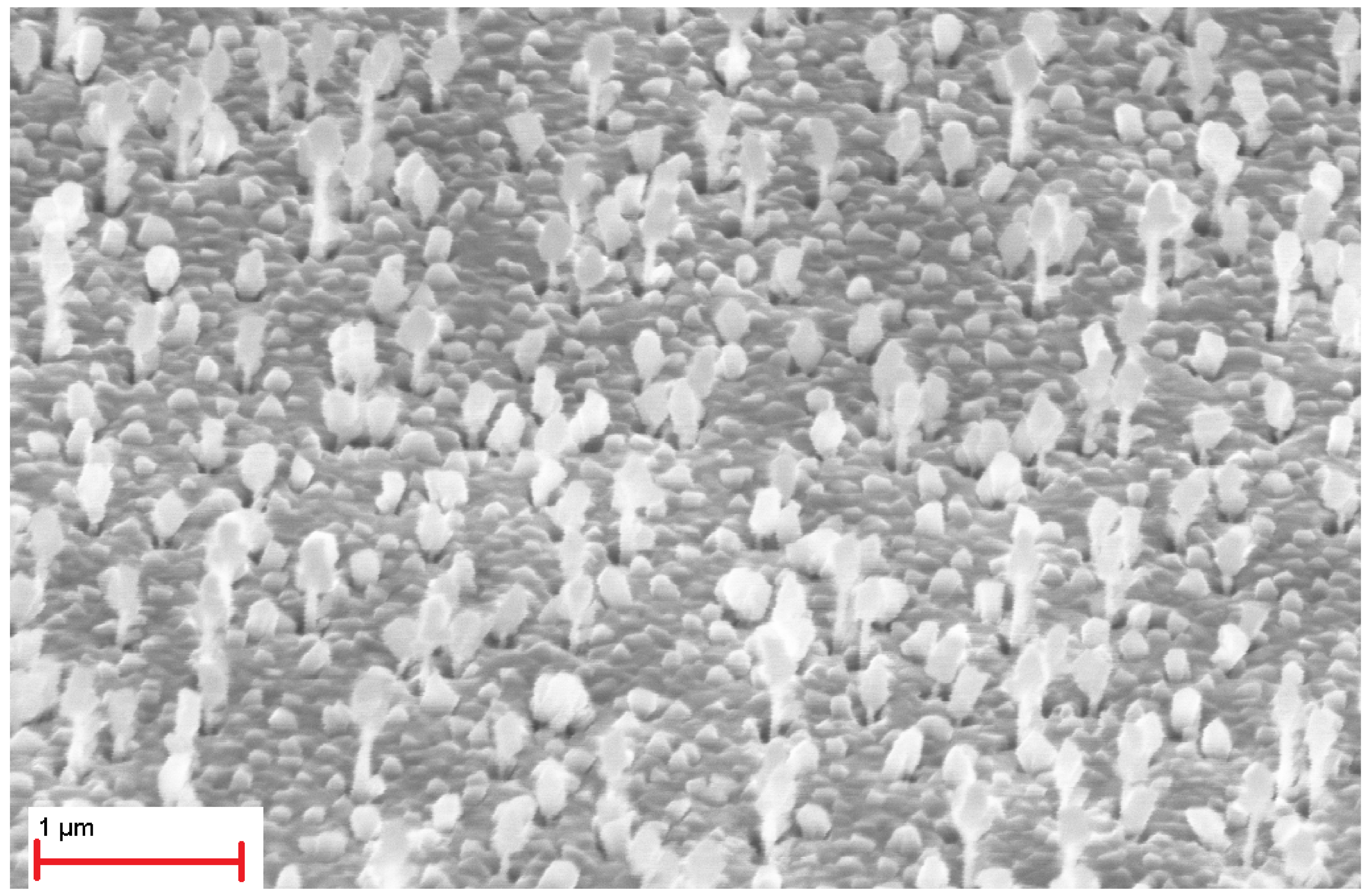
Calculations





Calculated surface recombination velocity[4] and specific series resistance of a passivated Si surface as function of the pitch between contact openings (top) and metal coverage (bottom), respectively.

Experimental Results



(Top) SEM-image of the nanopillar surface covered with Al **before** isotropic Si etching. The pillar density is ≈ 3 μm^{-2}, which corresponds to a potential metal to Si fraction of 2.4%.

SEM-image of the surface **after** isotropic RIE. The etching process has removed most of the nanopillars and created holes in the passivated Si surface covered with metal.

Conclusion

In this work, we present a completely maskless process allowing for controlled definition of local contact areas on a passivated Si surface without any use of lithography and with a submicron feature size and controllable pitch between contact openings. The metal to Si fraction was estimated to 2.4 % and the feature size a few hundred nanometers.
The method allows for a much lower pitch than lithographically defined patterns, while maintaining the targeted metal to Si fraction.
The technique has the potential for realizing advanced high-efficiency solar cell concepts, such as the PERL-cell, without the use of photolithography.

Rasmus S. Davidsen
PhD-student,
DTU Nanotech
Technical University of Denmark

Email: rasda@nanotech.dtu.dk
Phone: +45 26187249

DTU Nanotech
Department of Micro- and Nanotechnology

References

[1] Repo, P., Benick, J., Vähänissi, V., Schön, J., von Gastrow, G., Steinhauser, B., Schubert, M.C., Hermle, M., Savin, H., "N-type black silicon solar cells", SiliconPV, Energy Procedia 38 866-871 (2013).
[2] Davidsen, R., Ormstrup, J., Ommen, M.L., Larsen, P.E., Schmidt, M.S., Boisen, A., Nordseth, Ø., Hansen, O., "Angle resolved characterization of nanostructured and conventionally textured silicon solar cells", Solar Energy Materials & Solar Cells 1 40 (2015) 134–140
[3] Zhao, J., Wang, A., Green, M.A., "24.5% Efficiency silicon PERT cells on MCZ substrates and 24.7% efficiency PERL cells on FZ substrates." Prog. Photovoltaics: Research & Applications 7.6 (1999) 471-474
[4] Benick, J., Hoex, B., van de Sanden, M.C.M., Kessels, W.M.M., Schultz, O., Glunz, S.W., "High efficiency n -type Si solar cells on Al2O3-passivated boron emitters" Appl. Phys. Letters 92, 253504 (2008)